Wolfram Research: *Mathematica*

Tej Chajed
University Laboratory High School, Urbana
Teacher: Stephen E. Rayburn

Wolfram Research, based in Champaign, Illinois, is the well-known maker of *Mathematica*. *Mathematica* is a unique program that unifies all aspects of technical computing. Today, it has thousands of users, mainly in engineering, physics, and mathematics. *Mathematica* has improved in each successive version, giving it many uses in the modern world and making it a good software for technical computing.

Everything in *Mathematica* is represented symbolically; every expression and every operation is represented in *Mathematica* in the general form *head*[*arg1, arg2 ...*]. This symbolic representation is what makes *Mathematica* so integrated.

Mathematica integrates the many aspects of technical computing such as numerical calculations, symbolic calculations, and graphical operations, and allows them to be used together in programs or in calculations. Because of *Mathematica's* symbolic representation, each of these operations can be combined, making *Mathematica* flexible and easy to use. Another result of symbolic representation is that functions can be applied to many different elements, lists, matrices, numbers, variables, possibly even programs or entire files. In addition, *Mathematica* has a unique, 2-D math typesetting system that allows for easy entering of traditional math notation. The simplicity in a symbolic representation allows *Mathematica* to be used for both the simplest of calculations as well as cutting-edge research.

Mathematica has had many improvements since it was first released in 1988. In the former versions, 2.0 and 3.0, some basic functions were added and the math

typesetting system was made even easier to use. In the latter versions, 4.0 and 5.0, the changes were mostly improvements rather than new additions. However, both versions had something unique added to them. Version 4.0 had a specialized spell checker that was designed specially for the text entered in *Mathematica*. Version 5.0, on the other hand, introduced 64-bit computing (as opposed to 32-bit computing), which increased the raw processing power of *Mathematica* from version 5.0 onwards on the new, 64-bit computers.

Mathematica has many capabilities, which have been expanded through new functions in each successive version. The main three capabilities that *Mathematica* delivers are numerical, symbolic, and graphical calculation. Numerical calculation is any calculation involving no variables. This includes some calculus and trigonometry functions. Symbolic calculation includes all of numerical calculation plus expressions, using variables and having variables in the outputs. Also, there are many symbolic equation solvers, for nearly all types of equations, linear, nonlinear, and differential equations included. *Mathematica*'s graphical capabilities include graphing 2D and 3D functions, parametric functions, and even 3D animations. In addition, data from matrices, lists, tables, or files can be plotted, or an image file can be viewed.

Mathematica's user base is extremely large, and is spread across many fields. The three most prominent fields are engineering, physics, and mathematics, which make up roughly sixty-five percent of *Mathematica*'s users. In addition to these, people in finance/economics, social sciences, life sciences, and other fields use *Mathematica* and make up the remaining thirty-five percent of the users.

Many universities globally, have *Mathematica* on their campus. Professors and students use it in their work, and some courses even require it. Globally, over 70 universities have access to *Mathematica* on their campus.

Some industries have integrated *Mathematica* into their work. In engineering, both Apple and Boeing make use of *Mathematica* for their computations, as well as several others worldwide. Financial institutions, such as Fidelity Investments and Bank of America, also make use of it. Finally, some industries in biotechnology, such as Procter and Gamble and Merck and Co., have integrated *Mathematica* into their work.

However, *Mathematica* is not used only by industries and universities; others have made discoveries and achievements through *Mathematica*. One example is RTIS, Reed Technology and Information Services, Inc, which paired with Wolfram Research to create a system to typeset formulas in United States patents. This system is based on *Mathematica*'s math typesetting system, which makes it so easy to use. The same format was used by RTIS to create the system that is used to typeset and print every formula in every United States patent today.

Another user of *Mathematica* is the National Disaster Management Centre of South Africa. It created the National Disaster Hazard and Vulnerability Atlas, which predicts how a given natural disaster will affect the nation. This atlas uses user-fed information and web*Mathematica* (a form of *Mathematica* which allows all of its functionality to be put on a website) to calculate this data. Web*Mathematica* creates a very accessible feature that quickly and accurately predicts the vulnerability of any part or parts of the nation, saving lives by guiding evacuation.

In 1999, three researchers discovered the thirty-eighth Mersenne Prime, which are rare primes that are equivalent to a power of two minus one. They used an algorithm in *Mathematica* to find and prove that $2^{6,972,593}$-1 is prime. This won a $50,000 cash prize for being the first prime number to have over one million digits.

Mathematica has been improved several times in successive versions, but has always had capabilities for numeric, symbolic, and graphical calculation, as well as an easy system to enter these operations. These qualities give *Mathematica* a large and diverse assemblage of users that use *Mathematica* for a variety of uses in the modern world. [From Jerry Glynn and Theodore Gray, "I Never Learned to Spell. Can You Help Me?," The Beginner's Guide to Mathematica Version 4; Institutional Users of Mathematica, Wolfram Research, Inc. <http://www.wolfram.com/products/mathematica/usersanduses/institutions.html> (Dec. 13, 2005); Mathematica and Mersenne Primes, Wolfram Research, Inc. <http://www.wolfram.com/products/mathematica/usersanduses/experience/mersenne.html> (Dec. 13, 2005); Mathematica System Used to Process and Typeset Formulas in U.S. Patents, Wolfram Research, Inc. <http://www.wolfram.com/news/patents.html> (Dec. 15, 2005); Quick Revision History of Mathematica, Wolfram Research, Inc. <http://www.wolfram.com/products/mathematica/history.html> (Dec. 13, 2005); South Africa's National Disaster Atlas Uses webMathematica Technology to Fight Catastrophic Events, Wolfram Research, Inc. <http://www.wolfram.com/products/mathematica/usersanduses/experience/disasteratlas.html> (Dec. 14, 2005); The Unifying Idea of Mathematica, Wolfram Research, Inc. <http://www.wolfram.com/products/mathematica/tour/page14.html> (Dec. 14, 2005);

What Is Mathematica?, Wolfram Research, Inc.

<http://www.wolfram.com/products/mathematica/introduction.html> (Jan. 8, 2006).]